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Linking Social Perception and Provision of Ecosystem Services in a Sprawling Urban Landscape: A Case Study of Multan, Pakistan

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Abstract: Urban sprawl causes changes in land use and a decline in many ecosystem services. Understanding the spatial patterns of sprawl and exploration of citizens' perception towards the sporadic urban expansion and its impacts on an ecosystem to deliver services can help to guide land use planning and the conservation of the urban ecosystem. Here, we spatially examined land use changes in Multan, Pakistan, and investigated public perception about urban sprawl and its impacts on the quality and provision of ecosystem services, using a survey instrument. The spatial analysis of the historical land cover of Multan indicated an exponential expansion of the city in the last decade. Large areas of natural vegetation and agricultural land were converted to urban settlements in the past two decades. The citizens of Multan believe that the quality and provision of ecosystem services have declined in the recent past and strongly correlate the deteriorating ecosystem services with urban sprawl. Education and income levels of the respondents are the strongest predictors of urban ecosystem health literacy. Citizens associated with laborious outdoor jobs are more sensitive to the changes in ecosystem services. We concluded that the rapidly expanding cities, especially in the tropical arid zones, need to be prioritized for an increase in vegetation cover, and economically vulnerable settlements in these cities should be emphasized in climate change mitigation campaigns.

Keywords: urban sprawl; ecosystem services; climate change; public perception; land use change; Multan

1. Introduction

The contemporary world is increasingly urbanizing [1]. The global urban population is projected to nearly double between 2000 and 2030 (from 2.84 billion to 4.9 billion); the bigger concern, however, could be that the extent of urban areas is expected to expand three-fold within the same period [2]. Consequently, an unlimited, sporadic, and unplanned expansion of urban areas into natural environment (farmlands, forests, wetlands, etc.) has been reported, a phenomenon called urban sprawl [3,4]. Urban sprawl is feared to draw on natural resources and degrade the quality and provision of ecosystem services [2]. As stressed upon in international agreements, such as the Convention on Biodiversity, understanding the ecological consequences of urban sprawl and integrating the management of ecosystem services into developmental plans is central to sustainable management of the urban ecosystem [3,5].

Sporadic expansion of urban settlements and its impacts on the urban ecosystem has been widely documented [6,7]. Urban sprawl can cause significant environmental changes as major ecosystem services, such as the provision of food and raw material, conservation of soil and natural vegetation, hydrology and climate, carbon sequestration, and landscape aesthetic, may degrade as a result of rapid expansion of urban areas [1,4,5,8]. Urban sprawl is central to the issues surrounding sustainable urban development as it generates multiple impacts, like increased air and water pollution, and loss of local biodiversity and open areas with consequent detrimental effects on human health [9,10].

Several approaches have been proposed to assess the effects of unplanned urban expansion on environmental capital and to incorporate these assessments into urban management plans. For example, boundaries for projected future urban expansion have been assessed by gauging Environmental Carrying Capacity (ECC) of a landscape. ECC—often measured by indicators, such as ecological footprint and biocapacity [6,11]—verifies whether a given developmental plan is consistent with certain environmental targets, thus helping to devise environmentally-sustainable spatial plans for future urban development [12,13]. Ecosystem Services Bundles (ESB) is another concept proposed for identifying trade-offs and synergies between different ecosystem services based on the socio-cultural preferences of the stakeholders [14,15]. This approach has been used to identify areas in a landscape where human–environment interaction produces desirable or undesirable ecosystem services [15,16]. Recently, more multi-disciplinary indicators, such as Technomass [17] and Benefits Relevant Indicators (BRI) [18], have been proposed to link biophysical and social science approaches for measuring urban ecosystem services.

The growing concern about urban sprawl has led to policy formulation at a large scale [19–21]. Public concern about sprawl and its impacts on the provision of ecosystem services is germane to policymakers as the level of public concern is likely to affect the political and social acceptance of programs and policies [22]. Evidence suggests that the exploration of public perception and opinion offers opportunities to incorporate citizen awareness and needs that are traditionally missing in urban management [23]. Ecosystem services are often assessed through economic or biophysical indicators [24]; few attempts have been made to address the perspective of citizens' perception towards the evaluation of an ecosystem to deliver services [25]. Social evaluations help to understand the motivations behind preferences and opinions towards a problem, thus unveiling values that may otherwise remain unexplored by economic or biophysical assessment [26]. In this context, survey instruments have been successfully used to investigate indicators of public perception about the social and environmental impacts of urban sprawl [20]. A number of such surveys, like referenda, ballot measures, and polls, suggest that public concern about the environmental impacts of sporadic urban expansion has grown in recent years [22]. Socio-demographic factors, such as literacy [27], gender [28], age group [29], professional affiliation [30], and financial stability [31] of the citizens often shape public opinion about rapid urban expansion and associated social and environmental problems.

At the global scale, developing countries are hotspots of rapid urban expansion; 15 of the world's 20 most populous cities exist in these countries [32]. Although the consequences of urban sprawl are frequently reported in the developed countries [8,20,33,34], analyses of urban sprawl in developing countries, especially in Pakistan, remain scant. In Pakistan, the annual growth rate of urban population is nearly 2.5 percent, one of the fastest in South Asia [35]. Baseline studies are, therefore, needed to map the rapidly expanding urban landscape of the major cities in the country and to make a qualitative assessment of the socio-demographic factors that shape public opinion of urban sprawl and its impacts on the urban environment. A handful of studies on the urban expansion of some cities in the central and northern parts of Punjab province have recently been reported [31,36], however—to the best of our knowledge—there has been no study carried out in the southern parts of Punjab province, which is a speedily developing region of Pakistan. This study, therefore, adds to the literature by exploring the spatial, as well as social, dimensions of urban sprawl and their impacts on ecosystem services in southern Punjab, Pakistan. Specifically, three questions led our analysis:

1. To what extent does the public in the study area believe the quality and provision of ecosystem services has changed in the recent past (i.e., the past ten years)?
2. Having answered the first question, to what extent does the public believe that urban sprawl is responsible for the perceived changes in the quality and provision of ecosystem services?
3. What are the underlying socio-demographic causes for these individual opinions?

Additionally, we used GIS tools to visualize and quantify historical land use changes. In the last section, we discuss the implications of the findings for the sustainable urban management of the study area.

2. Methodology

This study comprised two methodological steps. In the first step, we quantified historical land use changes in the study area to identify the extent and patterns of rapid urban expansion and transitions between different land use classes. The second step comprised a survey study that investigated the perception of the local community about the changes in ecosystem services because of sporadic urban expansion in Multan.

2.1. Study Area

The main area for this study is the urban center of District Multan, i.e., Multan city. We chose this area primarily for two reasons: (1) Multan is one of the fastest expanding cities in Pakistan [32], yet there are no prior studies on the spatiotemporal changes in the landscape of the Multan region, and (2) Multan is located in the southern parts of Punjab province, which is reportedly amongst the most vulnerable parts of Pakistan to climate change [37,38]. The region has been in the spotlight in recent years because of extreme climate change events [39]. To generate a broader picture of land use change, we initially included District Lodhran and District Khanewal, the two adjoining administrative units of Multan (Figure 1), in the spatial analysis. Then, we restricted the survey to the city of Multan. The District Multan, which comprises Multan city, is one of the largest administrative units in Pakistan; it currently covers an area of 3720 km^2 and has a population of nearly 3.1 million, 42% of which live in Multan city [40].

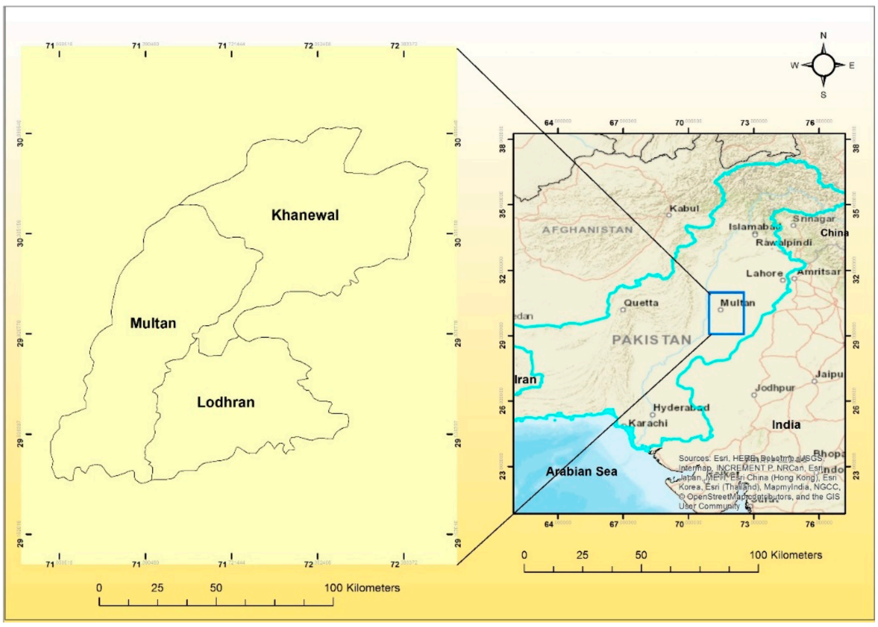

Figure 1. The case study site (District Multan and adjoining Districts of Khanewal and Lodhran). Geographic Coordinate System: GCS_WGS_1984, Datum: D_WGS_1984.

Step 1: Quantifying the Historic Land Use Change Patterns in Multan City

To quantify the historical land use changes, we downloaded land cover maps for the years 1992, 2002, and 2015 from "The European Space Agency CCI" global land cover product (www.esalandcover-cci.org). These global land cover maps, at a spatial resolution of 300 m, were masked to the extent of the study area using ESRI ArcGIS 10.6. As per the "The European Space Agency CCI" global land cover product symbology, the study area covered 21 different land cover types. For ease of analysis, we combined similar land cover classes (Supplementary Table S1) to produce five major land cover types: Arable land, Vegetation cover (tree/shrub), Urban area, Bare area, and Body of water. The area under each of these five land cover classes was computed for the year 1992, 2002, and 2015, followed by a comparative analysis of the land cover change during 1992–2002 and 2002–2015. Quantitative analysis of the change in the urban areas and the rest of the land cover classes was carried out following recommended protocols [41,42]. Furthermore, we used the land change modeler tool in TerrSet Geospatial Monitoring and Modelling Software to produce maps for the spatial trend of change. These maps helped to decipher the patterns and dimensions of land use transitions. The maps for spatial trends of change generalized the pattern of change by assigning a value of 0 to the areas of no change and a value of 1 to the areas of change.

Step 2: Perception of the Local Community about the Changes in Ecosystem Services as Affected by Urban Sprawl

After generating visual maps of historical urban expansion in the study area, we designed a survey instrument to query the perception of the local community of Multan city about the changes in ecosystem services as a consequence of urban sprawl in the last decade.

2.2. Design of the Survey Instrument

The survey was conducted in Multan following published protocols [43,44]. The survey consisted of 14 questions, the range of responses to all of which corresponded to the 5-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). These 14 questions were divided into two constructs of seven questions each (Table 1). Both constructs represent a theory-based concept [45]. The first construct comprised the questions about the perception of the respondents towards the changes in ecosystem services in Multan city in the last decade. The second construct was computed from the questions that determined the extent to which the respondents believed the observed changes in the ecosystem services were caused due to the sprawl of Multan city. Both the constructs were measured for internal consistency with Cronbach's alpha using Statistical Package for Social Scientists (SPSS) version 21.0 [46]. The explanatory variables in this study included gender (male/female), age group (youth/mature), profession (farming/other than farming), literacy (illiterate/literate), and the area of residence (urban/peri-urban) of the respondents. These variables were chosen after a detailed review of the published literature [27,28,31,47]. A detailed analysis of the explanatory variables is presented in Table 2.

Table 1. Constructs designed in the survey instrument.

Construct Name	Description	Questions	Average Response	Average Constructs	SE	Cronbach's Alpha
Perceived changes in ecosystem services	Whether the respondents believe there is a change in the provision of ecosystem services in Multan city	Air quality has decreased	4.65	4.13	0.49	0.71
		Water pollution has increased	4.4			
		Urban temperature has increased	4.21			
		The number of green spaces has decreased	4.09			
		Biodiversity has decreased	3.85			
		Agricultural land has decreased	4.13			
		Soil erosion has become more frequent	3.6			
Urban sprawl as a driver of changes in ecosystem services	Whether the respondents perceive urban sprawl as a causal agent for the changes in ecosystem services in Multan city	Air quality is affected by urban sprawl	4.3	3.77	0.59	0.64
		Water quality is affected by urban sprawl	4.35			
		Urban temperature is affected by urban sprawl	3.51			
		No. of green spaces is affected by urban sprawl	3.67			
		Biodiversity is affected by urban sprawl	3.7			
		Agricultural land is affected by urban sprawl	3.8			
		Urban sprawl drives soil erosion	3.1			

Table 2. Explanatory variables/demographic profile of the respondents.

	Demographic Characteristics (n = 148)	Frequency	Percent
Gender	Male	137	57.8
	Female	100	42.2
Age	Youth (18–35 years)	156	65.8
	Mature (>35 years)	81	34.2
Literacy	Illiterate	83	35
	Literate	154	65
Profession	Farming	61	25.7
	Others	176	74.3
Residential area	Urban	152	64.1
	Peri-Urban	85	35.9
Monthly Income	Low Income Class < $250	73	30.8
	High Income	164	69.2

2.3. Population Sampling

We used a stratified random sampling method for this survey study. We targeted the survey towards the urban and peri-urban areas of Multan, and within the urban and peri-urban areas, we randomly surveyed citizens belonging to different professions, categories of literacy, age groups, gender, and monthly income. The sample size for the survey was determined by the total population of Multan city (1.8 million), using the sample size calculation formula proposed by Yamane [48]. We set the confidence interval at 10% and used a 95% confidence level. With these parameters, the sample size derived was 100. We, however, recorded the responses of 237 respondents for this study. A map showing the spatial distribution of the respondents is shown in Supplementary Figure S1.

2.4. Statistical Analysis

The data obtained from the questionnaire were coded and entered into SPSS version 21.0 for descriptive and inferential statistics. We ran a multiple regression model to assess the factors affecting the perception of the residents of Multan about the changes in the ecosystem services of the city and the extent to which people hold urban sprawl responsible for these changes.

3. Results

Land use maps of the study area at three points in time, the year 1992, 2002, and 2015 are shown in Figure 2. Spatial analysis of these land use maps suggests that, in 1992, the urban area covered 1800 ha in Multan, which increased by 112.5%, extending to 3825.9 ha by 2002. A little over a decade later, in 2015, an exponential urban expansion occurred as the urban area reached 22,998.9 ha, which is a staggering 501.1% increase from the year 2002. Figure 3 shows an enlarged view of the area that experienced most of the urban sprawl. Among the other land use types, the arable land saw a reduction of 0.15% from 1992–2002 and a further decline of 1.59% by 2015. The vegetation cover declined, too; there was a reduction of 3.2% from 1992–2002, and by 2015, 7.4% of the remaining vegetation cover had disappeared. A quantitative analysis of the land use change is given in Table 3.

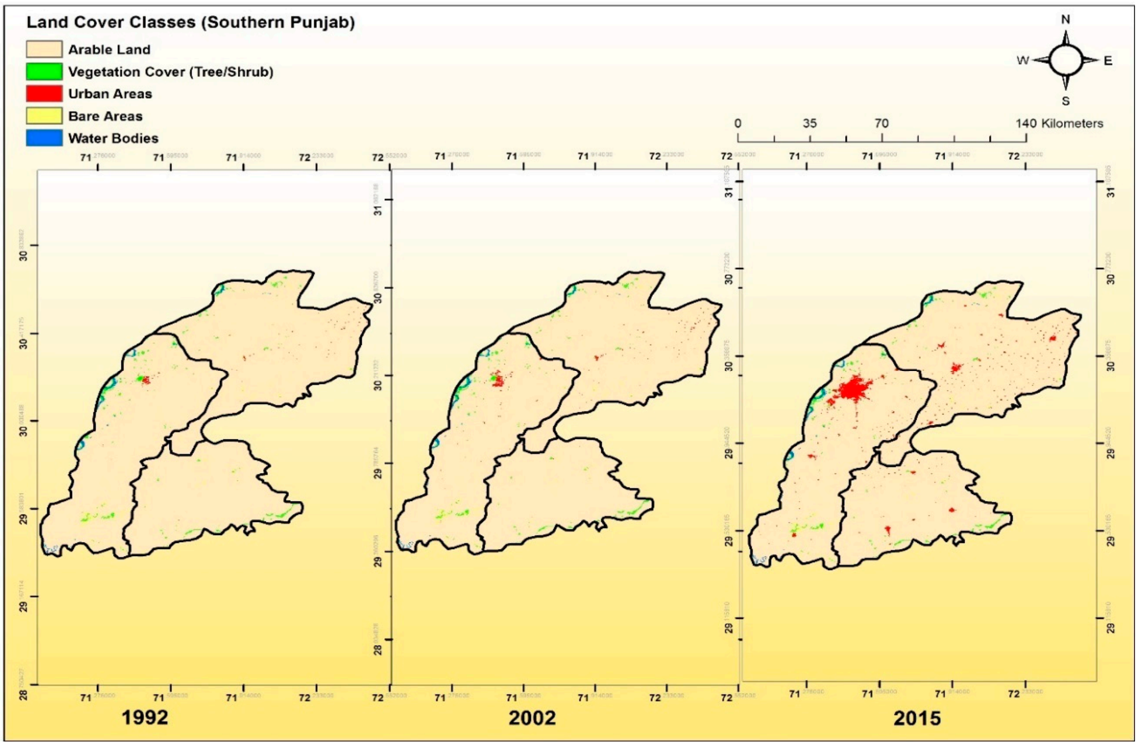

Figure 2. Spatiotemporal changes in the land use patterns of Multan city and adjoining areas (Khanewal and Lodhran) from the year 1992 to 2002 and 2015.

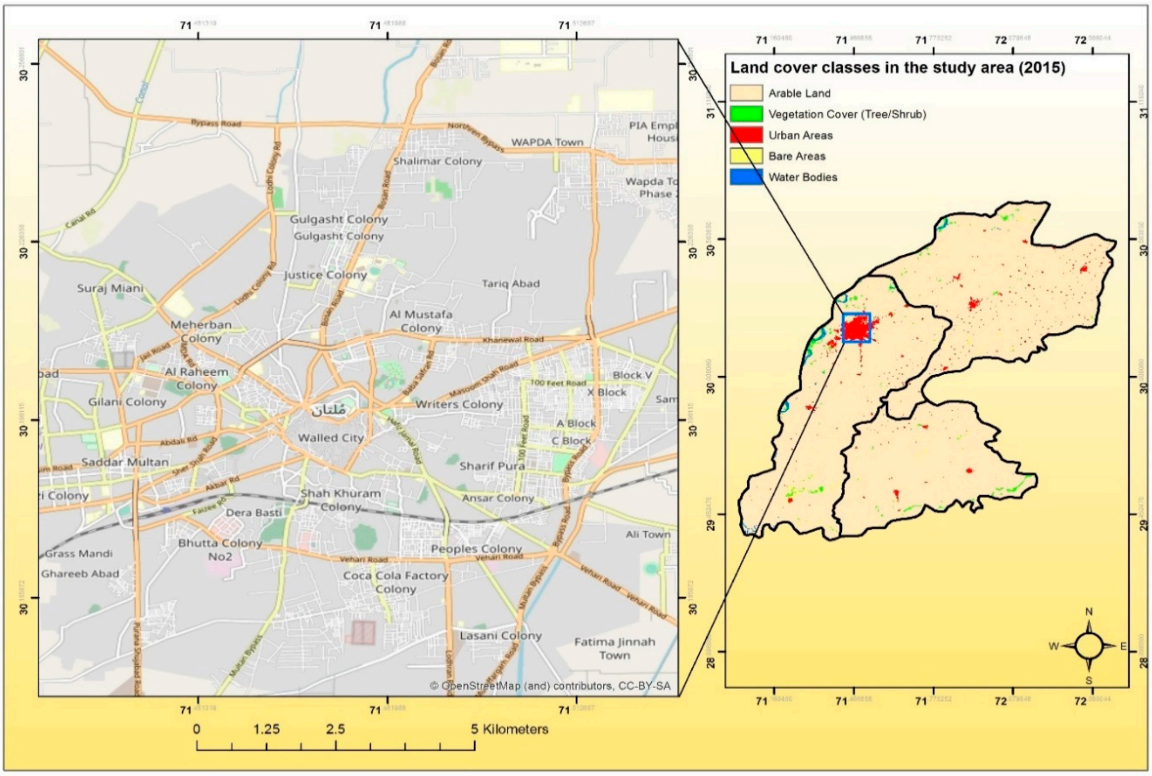

Figure 3. An enlarged view of the study area showing the site that experienced most of the urban sprawl.

Table 3. In selected cities of Southern Punjab (Multan, Khanewal, and Lodhran) area under different land cover classes (hectares) and change in the land use classes (1992, 2002, and 2015).

Land Cover Class	1992	2002	2015	Change (%)	Change (%)	Change (ha)	Change (ha)
				1992–2002	2002–2015	1992–2002	2002–2015
Arable land	1,123,652.20	1,121,903.70	1,103,968.40	−0.16	−1.6	−1748.5	−17935.3
Vegetation cover	12,845.40	12,438.60	11,529.70	−3.2	−7.4	−406.8	−908.9
Urban area	1800.4	3825.9	22,998.90	112.5	501.1	2025.5	19173
Bare area	7158.5	7054.6	6959.4	−1.5	−1.3	−103.9	−95.2
Body of water	4933.9	5167.6	4933.9	4.8	−4.5	233.7	−233.7

The preliminary spatial analysis (Table 3) indicated that urban area, arable land, and vegetation cover (tree/shrub) experienced most of the land use transition between 1992–2015. Further analysis revealed that the largest contribution to the net change in arable land and vegetation cover (tree/shrub) was that of urban area. Nearly 18,000 ha of arable land and 800 ha of vegetation cover (tree/shrub) that existed in 2002 was urbanized by 2015. Moreover, almost 150 ha of vegetation cover (tree/shrub) changed to arable land between 2002–2015. Detailed analysis of the contributions to the net change in these land use classes is presented in Supplementary Figure S2, while visual maps showing a spatial gain/loss in these land use classes are presented in Supplementary Figure S3. We also produced maps of the spatial trend of change which indicated that most of the conversion from arable land and vegetation cover (tree/shrub) was concentrated in the western parts of the study area (Figure 4).

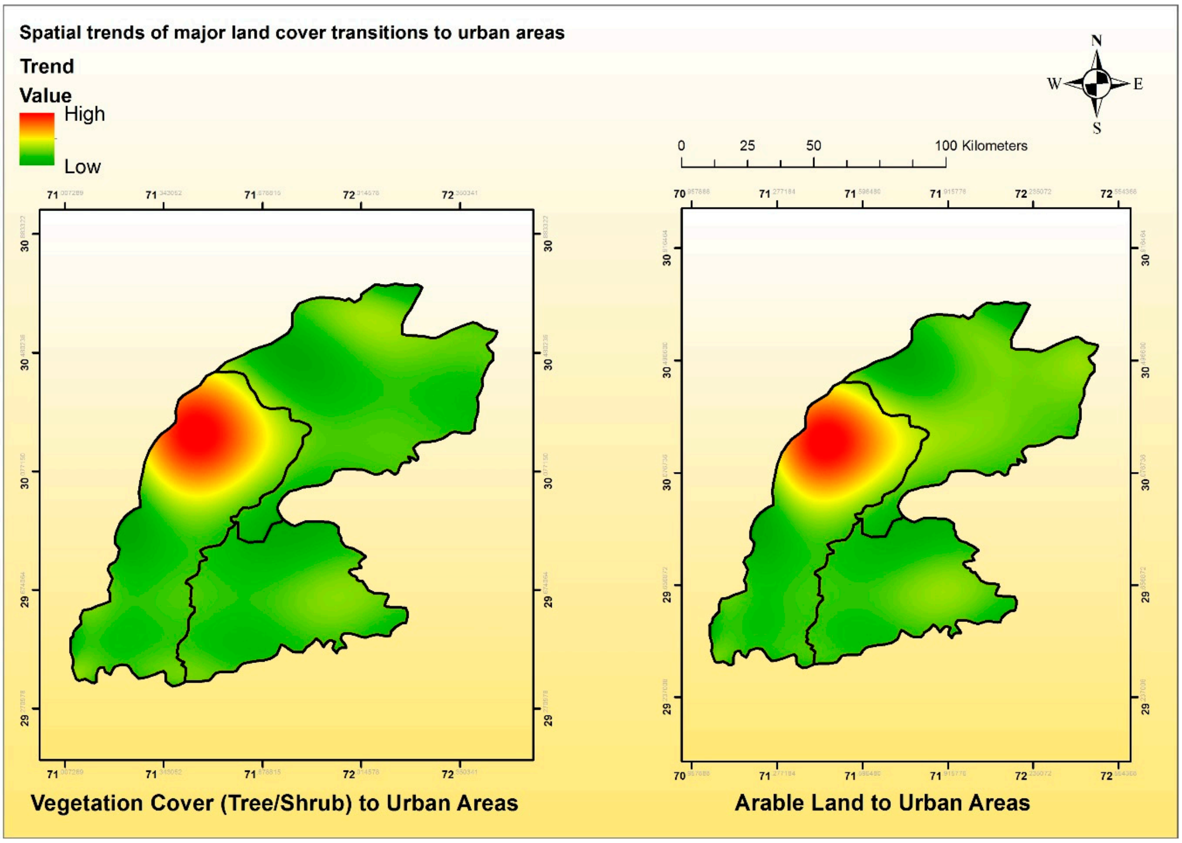

Figure 4. Maps of spatial trends of change from other land use classes to urban areas.

3.1. Understanding Public Perception of Urban Sprawl and Its Effects on the Provision of Ecosystem Services through Qualitative Analysis

3.1.1. The Demographic Profile of the Respondents

We received 237 usable responses from the respondents living in the central urban and peri-urban areas of Multan city. Demographic data of the survey respondents are presented in Table 2.

3.1.2. Constructs

Descriptive statistics for the two constructs created from the questions in the survey administered to the citizens of Multan (n = 237) are presented in Table 1. Scale for all constructs was 1 to 5, from strongly disagree (1) to strongly agree (5). The two constructs formed the two dependent variables of the study; the first construct/variable aimed to determine the perception of the citizens about the changes in the ecosystem services in the last decade, and the second construct formed a variable that gauged the extent to which the citizens believed that the observed changes in the ecosystem services are due to the urban sprawl. Both the constructs showed a dependable value of reliability test (Cronbach's alpha of 0.72 and 0.64), indicating a good degree of internal consistency.

3.1.3. Multiple Regression Model

The details of the multiple regression model parameters are shown in Table 4. In the first model, where we regressed the perception of the citizens about the change in ecosystem services in Multan against a range of independent variables, the model output suggested that our dependent variable was significantly affected by the levels of literacy and monthly income. When compared to the literate respondents, the illiterate citizens showed a significantly higher sensitivity towards the deteriorating ecosystem services in the Multan region ($\beta = -0.234$). Similarly, the respondents in the low-income category showed more awareness of this issue as compared to the high-income category respondents (β = −0.167).

Table 4. Multiple regression analysis results showing relationships between dependent and independent variables. Constructs were created from questions in a survey administered to the citizens of Multan (n = 237).

	Dependent Variables	Independent Variables	Unstandardized Regression Coefficient	Standardized Coefficient (Beta)	*p*-Value	R^2
Model 1	Perception about changes in ecosystem services in Multan	Gender	0.032	0.31	0.627	14.5
		Age	0.037	0.034	0.590	
		Literacy	−0.234	−0.22	0.001 *	
		Profession	0.094	0.081	0.243	
		Residential area	0.132	0.124	0.058	
		Income	−0.167	−0.151	0.024 *	
Model 2	Perception about urban sprawl as a driver of change in the ecosystem services in Multan	Gender	−0.031	−0.025	0.697	13.2
		Age	−0.020	−0.015	0.807	
		Literacy	−0.354	−0.275	0.001 *	
		Profession	−0.178	−0.126	0.064	
		Residential area	0.119	0.093	0.149	
		Income	0.05	0.04	0.539	

Note: * significant at $p < 0.05$.

In the second model where, against the same set of independent variables, we regressed a construct computed from the questions on the extent to which the citizens believed the perceived or observed changes in the ecosystem services are due to urban sprawl, literacy was a significantly important determinant. We found that illiterate respondents (β = −0.354) strongly believed that urban sprawl is the driving factor behind the declining ecosystem services in the Multan region. Detailed analysis of how responses within each demographic category varied is shown in the Supplementary Figures S4 and S5.

4. Discussion

Anthropogenic activities are the drivers of major changes in the modern world; the impact of rapidly expanding cities on environmental resources and ecosystem services is a notable example [49,50]. In the recent past, urban encroachment of natural ecosystems have increased exponentially and are expected to continue doing so; almost 60 percent of all the urban settlements that will exist by 2030 are forecast to be built during 2000 and 2030 [51]. The situation is even graver in developing countries where there is more of an *urban sprawl* than planned urban expansion [52]. This sprawl can be attributed to several drivers: Mounting population pressure, increase in human mobility, finding houses in relatively low-price areas, and search for livelihood opportunities, to name a few [53].

Rapid urban expansion is often seen as an indicator of economic development [54]; at the same time, it affects the environmental resources and provision of ecosystem services [55]. These effects may include a decrease in agricultural land, loss of biodiversity, increased greenhouse gases emissions, urban heat island effect, increase in municipal costs, spatial segregation of natural habitats, and noise, light, soil, and water pollution [7,56,57]. There is now a global interest to restore ecosystem services in urban areas, given international commitments, such as Convention on Global Biodiversity, for the restoration of at least 15 percent of degraded ecosystems by 2020 [58]. These also conform to United Nation's agenda on a green economy for the 21st century, as well as Sustainable Development Goals.

In this study, we analyzed the patterns of historical urban expansion in Multan, Pakistan, and investigated the perception of the local community about the changes in ecosystem services as affected by the urban sprawl. The GIS-based analysis of the land cover changes in Multan suggested that the urban areas speedily increased, especially in the last 15 years or so, resulting in a decline in the vegetative cover in the region. In an earlier study conducted in Islamabad, the capital of Pakistan, key changes in land use and land cover, such as an expansion of the urban areas, were reported [59]. These results are in line with the future projections suggesting that the majority of Pakistan's anticipated 250 million population will be residing in cities by 2030. Migration and high birth rates are the principal drivers of Pakistan's urban development. Access to better jobs and improved basic needs are a magnet for migrants [35].

The negative correlation of the provision and quality of ecosystem services with unplanned and sporadic urban expansion has been widely reported [7]. Based on this assumption, we speculated that the provision of urban ecosystem service in Multan has decreased in the recent past. To test this assumption, we carried out a survey-based study to inquire the perception of the citizens of Multan about changes in the ecosystem services, and their belief of urban sprawl as an agent of the observed changes in ecosystem services. Evidence suggests that urban sprawl has obvious effects on ecosystem services, such as water quality, microclimate, green spaces, and biodiversity [60]. Previous studies have suggested that urban vegetation is an important indicator of urban ecosystem health and is often seen as a measure of the quality and provision of urban ecosystem services [60,61]. Urban green spaces are often strongly correlated to landscape aesthetics and psychological health of the citizens [62]. The results of our spatial analysis indicated a decline in vegetation cover between 1992–2015. Subsequently, the survey results suggested that citizens of Multan strongly believe that air and water quality and green spaces have reduced in the recent past, which corresponds to the assumption that decreasing vegetation cover has obvious effects on the quality and provision of ecosystem services. Similarly, urban infrastructure can influence the urban microclimate by increasing air pollution, creating heat stress, changing wind direction and speed, and altering surface ozone concentration [60,63]. Urban sprawl has been reported to increase the urban temperature, a phenomenon known as the Urban Heat Island Effect [60]. Spatial analysis of Multan city indicated a rapid expansion of the footprint in the last couple of decades, and the effects of this expansion were reflected in the survey study where the citizens not only showed strong agreement that the urban temperature of Multan has increased but also agreed that the increasing urban temperature is strongly correlated to the urban sprawl.

Furthermore, we investigated the socioeconomic factors determining the public sensitivity towards the urban ecosystem services and the extent to which people believed those changes are caused by urban sprawl. For the first dependent variable—the public sensitivity or perception about changes in the ecosystem services—the results suggested that the citizens of Multan strongly believe that urban environmental resources and ecosystem services have decreased in the last decade or so (a score of 4.13 on a scale of 1 to 5). We found that education and income level were the two significant predictors for this dependent variable. The respondents in Multan city who had a formal education of high school or above were significantly less sensitive to urban environmental change. This result contradicts the general perception that awareness of changes in ecosystem services is strongly correlated with higher formal education. In a global survey where respondents from 119 countries were investigated for the relative effects of socio-demographic characteristics on public climate change awareness, educational attainment was reported as the single strongest predictor of climate change awareness [27]. We believe that our results may have diverged from the general trend because of three reasons. Firstly, most of the survey studies on climate literacy so far have been based on responses from America, Europe, and UK, and only a handful of such studies have investigated the dimensions of public opinion in the developing counties of Asia. The results of the global survey discussed above [27] suggested that education was the strongest predictor for American and European respondents, while in Asian and African countries, education did not have a significant role in shaping public perception of climate change, although the authors concluded that education is a strong overall predictor. Secondly, the least educated citizens in Multan—and most developing countries—are often associated with laborious outdoor jobs. Given that Multan is one of the hottest cities in the world, it is natural for those most exposed to the environment to be more sensitive to the changes in such ecosystem services as precipitation, temperature, atmospheric pollution, and others. Thirdly, our results indicated that the respondents with low-income levels are significantly more sensitive to the changes in ecosystem services in Multan city. Again, we found that this predictor had not been reported as a significant predictor of climate change awareness in the developed countries [18]. However, survey studies conducted in many developing countries—especially in tropical agroclimatic zones, such as Bangladesh and Kenya—household income is a very strong predictor of climate literacy [19,20,64,65]. This may be attributed to the fact that high-income individuals and families can afford means to combat extreme hot and cold temperatures (through better heating and air conditioning facilities) and often dwell in areas with better green infrastructures. Low-income citizens are often more exposed to the natural environment and, therefore, may show greater sensitivity towards changes in the ecosystem services. For the second dependent variable—the extent to which the respondents believed changes in the ecosystem services are due to urban sprawl – the respondents showed strong agreement (a score of 3.77 on a scale of 1 to 5). We found that the least educated citizens were more convinced of that fact that the observed changes in the ecosystem services are caused by the urban sprawl. We assume that this trend can be attributed to the same argument: The least educated citizens are often associated with outdoor physically laborious jobs, which tends to make them more exposed to the urban environment.

Limitations of the Study

Although this study provided insights into the spatiotemporal patterns of rapid urban expansion in Multan, it is, however, acknowledged that the spatial analysis was based on land cover maps of 300 m grain size. Considering the scale of the study area, a finer grain size (i.e., 30 m) might reveal more information and a better understanding of the dimensions and amount of urban sprawl [66,67]. We also recommend generating future land cover change projection using ensemble modeling approaches, such as the Markov Chain-Multi layer perceptron [33,41]. Future land cover projections might help stakeholders and policymakers to prioritize areas of urban ecosystem conservation. Furthermore, we used six socio-economic variables to explain the variations in the public awareness of changes in the ecosystem services as affected by urban sprawl. In both the regression models, although we found significant predictors among the chosen explanatory variables, the overall variation in the responses explained by the predictors (R^2 value) remained low, which means that there may be other underlying explanatory variables. For this, we recommend including more variables in future studies to better explore the drivers underpinning public understanding of urban sprawl and how it affects urban environment. We also acknowledge that the sample size for the survey conducted was, although statistically acceptable, not large enough to draw concrete conclusions. For future studies, we recommend taking a larger sample size (500–1000) for more comprehensive conclusions [31].

5. Conclusions

In this study, we assessed the magnitude of city expansion and other land use changes in the recent past. We explored the citizen perception about the quality and provision of ecosystem services and its association with urban sprawl. The respondents of Multan strongly believe that the quality and provision of the ecosystem services in Multan has deteriorated in the last ten years or so, and they hold urban sprawl as one of the main factors responsible for this deterioration. Among the demographic characteristics of the respondents considered in this study, the economically vulnerable and least educated citizens are the most sensitive to environmental changes in the Multan region; however, the regression model suggests that there may be other important demographic and socioeconomic traits which need to be explored in future studies. Future policies of urban environmental management need to focus more on the middle class and lower-middle-class settlements in the city. The government of Pakistan, following its successful completion of the Billion Tree Tsunami is the North Western part of Pakistan (Khyber Pakhtunkhwa) [68], has started an initiative to plant 10 billion trees in the country to mitigate climate change impacts. Cities like Multan, which are not only facing extreme climate change but an additional burden of deteriorating ecosystem services as a consequence of urban sprawl, should be prioritized in the tree-planting campaigns.

Supplementary Materials: The following are available online at http://www.mdpi.com/2071-1050/11/3/654/s1: Figure S1: Domicile location of respondents interviewed in the study area; Figure S2: Contribution to net change of land use observed in Multan region between 2002–2015(in hectares); Figure S3: Map of the study area showing gain/loss in the land area under the land cover classes, a) urban areas, b) arable land, and c) vegetation cover (tree/shrub) during 2002–2015; Figure S4: Bar Chart showing average responses within each demographic category to the questions on whether the respondents have observed changes in the ecosystem services in the study area; Figure S5. Bar Chart showing average responses within each demographic category to the questions on whether urban sprawl is responsible for changes in ecosystem services in the study area; Table S1: Reclassification of the European Space Agency (ESA) Land cover map for this study. Land cover classes shown in the same color were merged for spatial analysis in this study.

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